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Developmental Coordination Disorder, Age, and Play: A Test of the Divergence in Activity-Deficit With Age Hypothesis

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The purpose of this study is to test whether the activity-deficit experienced by children with probable Developmental Coordination Disorder (DCD) increases with age. We use a sample of children ages 9 to 14 (N = 581) to examine whether age influences the relationship between DCD and participation in free play and organized activities. Consistent with previous work (Bouffard et al., 1996), we found no evidence to support the hypothesis that children with DCD become more inactive compared to their peers as they age; however, we do discuss the limitations in our sample and how some differences in the level of organized and free play activity are evident among cohorts of different ages. Directions for future research in this area are also discussed.

Developmental Coordination Disorder (DCD) is characterized by poor motor proficiency that is associated with significant impairment to both social and academic functioning (American Psychiatric Association, 2000). In the absence of an identifiable lesion or pathogen, the diagnosis of DCD is made when known existing neurological conditions (e.g., Cerebral Palsy) and intellectual impairments (e.g., Pervasive Developmental Disorder) are not present or have been taken into account. It has been estimated that between 5% and 9% of all school age children meet the

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diagnostic criteria for DCD (American Psychiatric Association, 2000; Kadesjö & Gillberg, 1999; Sugden & Wright, 1998; Wall, Reid, & Paton 1990), making it one of the most prevalent childhood developmental disorders. It is comparable in prevalence, for example, to dyslexia and attention-deficit-hyperactivity disorder and is considerably more common than autism or autism spectrum disorders (American Psychiatric Association, 2000). The specific manifestations of the disorder are varied and pervasive including both gross and fine motor skills (Visser, 2003). These problems make day-to-day activities such as tying shoelaces, handwriting, and participating in activities such as skipping or basketball extremely difficult, if not impossible. It is not surprising, therefore, that children with DCD tend to participate less in social activities than do other children (Chen & Cohn, 2003).

Children with DCD are also less likely to be physically active than are children without the disorder (Bouffard, Watkinson, Thompson, Causgrove Dunn, & Romanow, 1996; Cantell, Smyth, & Ahonen 1994; Gubbay, 1975; Hands & Larkin, 2002; Schoemaker & Kalverboer 1994; Wall, 1982). Bar-Or (1983) referred to this as the activity deficit hypothesis. The deficit occurs most likely because children with movement problems often lack confidence in their physical abilities (Cantell et al., 1994; Losse et al., 1991; Piek, Dworcan, Barret, & Coleman, 2000; Rose, Larkin, & Berger, 1997; Shoemaker & Kalverboer, 1994; Skinner & Piek, 2001), have a lower sense of self-efficacy toward physical activity (Cairney, Hay, Faught, Wade et al., 2005; Hay, 1992), and/or because they are excluded from such activities by their peers (Hay & Missiuna, 1998). The environment (e.g., autonomy supported physical education classes) is also an important factor in determining whether children with motoric problems participate in physically active pursuits (Bouffard et al., 1996). However, unlike other conditions that cause movement problems in children, such as Cerebral Palsy or Muscular Dystrophy, DCD is often not regarded by parents or teachers as a condition requiring intervention or special accommodation (Hay & Missiuna, 1998). Children with DCD are often looked upon as clumsy, unmotivated, and/or lazy, or their problems are assumed to be the result of other conditions such as attention-deficit disorder or a learning disability. Children with DCD form a "hidden cohort" at risk of social exclusion and ridicule from other children (Hay & Missiuna, 1998).

The long-term consequences of DCD are not favorable. Compared to their motor-proficient peers, children and adolescents with DCD are more likely to perform poorly in school, to leave school early, and are at greater risk for emotional and behavioral problems as they age (Cantell et al., 1994; Losse et al., 1991; Sugden & Wright, 1998). Since children with DCD are unlikely to out grow their coordination difficulties (Cantell, Smyth, & Ahonen, 2003), the negative consequences and behavioral responses that occur in childhood and adolescence are likely to persist into adulthood. This is of concern, particularly in relation to their levels of physical activity and the related consequences of hypo-activity. For example, in addition to being less physically active, children with DCD are more likely to be obese (Cairney, Hay, Faught, & Hawes, 2005) and have lower cardio-respiratory fitness levels than children without the condition (Faught, Hay, Cairney & Flouris, 2005). If these conditions persist into adulthood, then children with DCD may be at greater risk for cardio and cerebral vascular related diseases later in life. Identifying the factors that influence their participation in physical activity is critical for intervention.

Although it seems probable that children with DCD will be less likely to participate in activities such as organized sports and physical education class, or engage in free play pursuits than children without the disorder, several important questions remain. One line of inquiry pursues the issue of whether factors such as gender and age influence the impact of the disorder on physical activity. For example, boys and girls differ in the relative importance they place on physical activity (Chase & Drummer, 1992; Figler &Whitaker, 1991; Greendorfer, Lewko, & Rosengren, 1996), as well as the kinds of activities in which they engage (Best, Blackhurst, & Makosky, 1992; Klentrou, Hay, & Plyley, 2003). Several studies have examined the impact of gender on the relationship between DCD, play, and orientations toward activity and sport (Cairney, Hay, Faught, Mandigo, & Flouris, 2005; Rose, Larkin, & Berger, 1998). Rose, Larkin, and Berger (1998), for example, found that girls with coordination problems reported the lowest levels of athletic competence of all children in their sample (boys with coordination problems, girls and boys without coordination difficulties). Similarly, Cairney, Hay, Faught, Mandigo, and Flouris (2005) found girls with probable DCD to have the lowest scores of all children in their sample on measures of generalized self-efficacy toward physical activity and the lowest levels of participation in both free play and organized activities (compared to boys with DCD and a sample of children without coordination problems). These studies highlight the importance of considering the role that gender plays in influencing physical activity among children with coordination problems.

Age is another variable of interest to researchers studying DCD (Bouffard et al., 1996; Wall, 2004). However, to date, very few studies have examined whether age exerts an influence on the impact of DCD in the daily life of children. Several researchers have suggested that the activity-deficit in children with movement problems will grow larger as children's play becomes more complex and rule-bound (Bouffard et al., 1996; Wall, 1982; Wall, 2004). In a recent paper by Wall (2004), the skill-learning gap hypothesis was presented as further elaboration of the divergence in activity deficit with age that occurs in children with movement difficulties. He states that the gap in skill-learning between children with less physical skill and their peers will widen as the latter group will generally achieve greater expertise and begin to participate in ever more demanding physical activities. As "challenging learning and performing environments" (Wall, 2004, p. 210) become the norm, children with coordination difficulties will find it increasingly more difficult to participate. Reduced participation will invariably lead to curtailed skill development, and as a result, children with motoric difficulties may eventually disengage altogether from the physical activities of their peers. Unable to follow the typical course of development in the acquisition and application of complex physical skills, they will not be able to learn the higher-order strategic skills required for participation in complex play activities. Their withdrawal from such activities only compounds the problem. The skill-learning gap hypothesis describes the process whereby the activity-deficit between children with and without coordination problems widens with age. As Wall (2004) notes, however, more empirical work is required to test this hypothesis. To our knowledge, there has only been one direct test of the divergence in activity deficit with age hypothesis (Bouffard et al., 1996). Based on observational data, Bouffard and his colleagues (1996) reported that children with movement problems (defined as a score of at least 4.0 on the Test of Motor Impairment) were much less likely to play vigorous, active games, use large playground equipment, were more likely to spend time alone, and were more likely to be "unobservable," meaning they were not visible to the researcher during recess. Their findings support the activity-deficit hypothesis for unstructured (recess) play in children. However, they did not find that play patterns between children with movement problems and those without differed across age groups.

Although it would appear from the study identified above that the divergence in activity with age hypothesis is not supported, there are at least two reasons to reexamine this hypothesis among children with DCD. First, although Bouffard and his colleagues (1996) failed to find age differences in play patterns, the age range of their sample was relatively narrow (approximately 4 years, ages 6 to 9). These age ranges correspond to Grades1-4 in the primary system in Canada. Although the differences in play between a 6-year-old and a 9-year-old are apt to be quite different, the degree of complexity in play might not be quite as dramatic during this period (grades 1 to 4) when compared to other transitional periods (with children from grades 4-8). Specific motor skill development (e.g., running or throwing a ball) increases more rapidly between ages 9 to 16 than the period between ages 4 to 9 (Haywood, 1986). Moreover, maturational and psychosocial changes during the transition from childhood to adolescence may have a profound impact on the kinds of activities children participate in, both during their free time and in terms of organized activities. Therefore, it is important to include a broader age range to ensure that critical age-related differences in play can be captured.

Second, Bouffard et al. (1996) focused only on the analysis of free time or unstructured play. It may be that age differences in free play between children with motoric difficulties and those without remain relatively constant because of the discretionary control children can assert over their activities. In other words, children with DCD may select activities, either by choice or because they are excluded from certain play situations by their peers, that are less complex than their peers as they age, thus remaining physically active, albeit in less demanding activities. If children without DCD increasingly substitute simpler games and activities with more complex play as they age, the quality (or nature) of play may change between children with and without DCD, even though the relative difference in participation will remain unaffected (i.e., children with DCD at all ages are less active than other children but the difference is constant; Wall, 2004). Alternatively, for more structured or organized activities, the activity-deficit with age hypothesis is more plausible. Take, for example, the changes that occur in the level/complexity of skill in a game such as baseball or softball across successively older age groups. It is possible that a child in grade 4 with movement difficulties may still participate in the game because the overall level of play (i.e., average degree of complexity) in the group is still relatively low. A child could play in the outfield and almost never have to make a catch or throw. However, in the same game played by a group of 13 to 14-year-olds, the overall skill level is quite different. It would be unlikely that an adolescent with DCD would be able to find a position on a competitive, organized team (school or community) that did not require motoric skills beyond their capabilities. As a result, we may expect that for organized or structured activities, older children with DCD may report even lower levels of participation than both younger children with DCD and those children without movement difficulties. It is important to note, however, that we are not implying that only structured activities are complex. There are many free play activities (e.g., skiing, golf) that require complex skills but that occur in a reasonably static or predictable environment. These more "closed" motor skills allow a child to focus more on movement production and less on the strategies required in a changing game environment. The important point is that if given the choice, children with DCD will opt for less complex activities. Because many of the organized activities that children participate in are team-based and highly skilled, we anticipate there may be a difference in the reporting of participation in free play and organized activities with age between children with DCD and those without.

Method

Participants

The study involved a cross-sectional investigation of all students in grades 4-8 from five elementary schools in the Niagara Region of Ontario, Canada. Although the schools represent a non-random sample, particular attention was given in the selection of schools to ensure that the participants represented the socioeconomic, ethnic, and urban or rural groups as they occur in the Canadian population. Consequently, although the cohort was multi-raced, the majority of the participants were Caucasian. Further, a large number of participants were middle-class, urban dwellers. Eight children with previously known learning disorders were allowed to take part but were excluded from the analyses. Eighteen children with preexisting medical conditions, excluded from physical education classes due to medical reasons, were excluded. A total of 590 children (322 males, 268 females) provided informed consent (parental consent also) and participated in the study from a potential sample of 929 (63.62% response rate). After deletion of cases with missing values, 581 children had complete data for analysis. This sample represented 12.4% of all 9- to 14-year-old children living in the city of St. Catharines (the major urban center in the Niagara Region; Statistics Canada, 2001). The age range of the sample was 9 to 14 years, and the mean age was 11.46 (SD = 1.46).

In this sample, 7.5% ($n = 44$) of the children met the requirements for probable DCD. Of these children, 57% were girls ($n = 25$) and 43% were boys ($n = 19$). We found no significant differences in DCD prevalence between boys and girls ($X^2 = 2.582$, $df = 1$, $p = .108$). Our findings with regard to gender differences in the prevalence of DCD are consistent with some (Coleman, Piek, & Livesey, 2001; Dewey et al., 2002), but not all population-based studies (Sugden & Chambers, 2003, 2005; Wright & Sugden, 1996, 1998).

Procedures

All testing took place in the schools. Children were first administered a survey in the homeroom class and then completed the fitness testing, anthropometric assessments, and motor proficiency battery in the school gymnasium. Trained research assistants carried out all assessments on the same day, with the Bruininks-Oseretsky test of motor proficiency (BOTMP) being the final assessment. Therefore the research assistants were blind to children's motor capacity for all testing. The research assistants who administered the fitness assessment were also blind to the results of the survey as they were not scored until a later date.

Dependent Variable

Physical Activity/Play. The Participation Questionnaire (PQ) contains 16 items that provide a frequency estimation of children's participation in the areas of free-time play and recreation, intra-mural sports, inter-school sports, community sports teams and clubs (dance/swim/tennis), and sport and dance lessons (Hay, 1992). Of these items, nine provide an inventory of free-time activities, and six catalogue organized athletic and recreational opportunities. These items are used to provide a global frequency assessment in "activity units" of children's physical activity. Additional items are concerned with demographic variables, inactive pursuits, and probe the intensity and duration of participation and are not employed for the purpose of frequency estimation. Participation in organized activities encompasses a one-year period, and free play is recalled from typical pastime choices at the time of completion. Subtotals are available for unorganized activity (free play) and organized activity (sports teams, clubs, lessons). The PQ measures activity units, which are defined as an active pursuit that is regularly selected in free play/recreational situations and/or enrolment in an organized sport team, club, or lesson. The PQ provides an estimation of a child's frequency and nature of physical activity, but does not address overall intensity or duration. The resulting activity unit summaries are referred to as Free Play (where children are free to select an active pursuit from the universe of options) or Organized Activity/Sport (which are situations requiring enrolment or authorization by a care-giver or teacher) and are totaled to provide a complete picture of a child's typical activity level.

The PQ was initially developed following a survey of all available instruments and is based on items developed in conjunction with parents, teachers, physical activity experts, and children. All were located in Southern Ontario as are the subjects of this investigation. The PQ was initially tested with 543 children, revised based on their feedback and teacher comments, and subsequently administered to a further 507 children in grades 4 to 8 for the evaluation of psychometric qualities. This revised PQ has consistently demonstrated strong construct validity with expected significant gender differences and urban/rural differences present (Hay 1992; Hay, Hawes, & Faught, 2004; Hay & Donnelly, 1996; Klentrou, Hay, & Plyley, 2003) and significant correlations with body fat, aerobic capacity, motoric competence, and other health outcomes (Klentrou et al., 2003). Criterion validity is very difficult to establish with any measure of physical activity; however, the PQ has demonstrated significant (.62) correlations with teacher evaluations of activity (Hay, 1992; Hay & Donnelly, 1996). Reliability of the Participation Questionnaire among elementary school children was established with a test-retest reliability of 0.81 (Hay, 1992). The population used to develop and evaluate the PQ was highly similar to the cohort described in this study with identical class-room administration procedures employed, and the overall results are not dissimilar. The PQ has been employed well within its validity constraints for both population and purpose as described by Yun and Ulrich (2002).

With regard to reliability, the PQ is an index of participation (similar to a count of symptoms variable commonly employed in psychology and psychiatry), not a scale, and, therefore, measures of internal reliability such as Cronbach's alpha are not appropriate. Although we did not assess test–retest reliability in this sample, as noted above, the original instrument development on the PQ was conducted on a sample drawn from the same population of children (9- to 14-year-olds, grades 4 to 8), from the same region of the country (southwestern Ontario), and identical gender distribution (Hay, 1992). As such, we feel that the samples are very similar and that it is reasonable to infer that the reliability estimates derived by Hay (1992) also apply here.

For this study, we use both sub-indices (free play and organized activities) as dependent measures (Free Play: $M = 14.35$, $SD = 4.52$, $min = 0$, $max = 28$; Organized Activities: $M = 5.26$, $SD = 5.48$, $min = 0$, $max = 22$).

Independent Variables

Developmental Coordination Disorder (DCD). Motor proficiency was evaluated using the short form Bruininks-Oseretsky Test of Motor Proficiency (BOTMP-SF). This test examines the full scope of motor proficiency (static and dynamic balance, reaction time, bilateral coordination, etc.) using selected items from the full scale. The short form has been validated against the full scale with inter-correlations between .90 and .91 for children in the 8 to 14 age range (Bruininks, 1978). It was designed for use when large numbers of children are surveyed as it takes 30 min to complete as opposed to two hours for the full version. While not providing an in-depth analysis of each aspect of motor proficiency, it does provide an excellent assessment of general motor functioning. The BOTMP-SF was individually administered to each consenting child in the school's gymnasium behind a curtained barrier to ensure confidentiality. A BOTMP-SF standard score (age adjusted) below 38 was required to classify a diagnosis for probable DCD. Children who score below 38 are at or below the 10th percentile rank on the BOTMP-SF.

We use the term probable DCD because our method of case identification is a field test administered by trained researchers, not a diagnostic protocol administered by a licensed health care professional (e.g., pediatrician or occupational therapist). Moreover, although our case-identification method follows most of the criteria stipulated in the DSM-IV (American Psychiatric Association, 2000), it is not complete. The DSM-IV stipulates four criteria for the diagnosis: (a) significant motor impairment below the age-expected norms must be present; (b) motor problems must result in significant impairment to activities of daily living and/or academic achievement/performance; (c) condition cannot be due to other known physical conditions (e.g. cerebral palsy, muscular dystrophy) or pervasive developmental delay; and finally (d) if mental retardation is present, motor impairments must be below the norm (age appropriate) expected for these children. In this study, the BOTMP-SF is used for criterion (a), and, as mentioned in the discussion of the participants, all children with known learning disabilities and physical health problems were excluded from the analyses (Criterion c and d). Criterion (b), limitations in activities of daily living, is the only part of the diagnosis we did not measure. Unfortunately, while some research does take into account criterion (b) (e.g., Sugden & Chambers, 2003), as Visser (2003) notes, many studies do not. Although future research will need to address this problem, we elected to use the term probable DCD so our work can be compared to other studies.

Gender (males = 1, females = 0) and age in years (from 9 to 14), height (m) and weight (kg) are included as variables and covariates in the analyses. Height and weight were measured using a calibrated hospital scale and stadiometer. Because there were only 44 children with DCD in the sample, we re-coded age into 2-year intervals (9 to 10, 11 to 12, 13 to 14) to create three age groups for the analyses.

Analysis

In this study, we use a 2 (DCD – DCD vs. non-DCD) by 3 (Age Groups) ANCOVA with gender, height, and weight as covariates to examine both the main effects of DCD and age and the interaction between them for two outcome measures: free play participation and participation in organized activities. The minimum alpha level is set at $p < 0.05$ for statistical significance. We also report partial eta squared (η^2) to indicate relative effect sizes. Following Cohen and his colleagues (Cohen 1977; Cohen, Cohen, West, & Aiken, 2003), we regard a .01 value as the lowest value to represent a small, but meaningful effect. Because the Organized Activities sub-index was positively skewed, we used a non-parametric test (Mantel-Hanzel) to test for an interaction between DCD and age. All analyses were performed using SPSS v. 12.0.

Results

Results of the ANCOVA are presented in Table 1. Because we are interested in the effect of age on the relationship between DCD and participation in organized and free play activities, and because there is only one other study that has specifically examined this issue, we report means by age group for both outcomes for children with and without probable DCD.

Participation in Organized Activities and Free Play

Although there is a main effect of DCD on organized play, there is no evidence of either a main effect of age or an age by DCD interaction in predicting participation in organized play. However, a visual inspection of the data in Table 2 (the standard deviation is larger than the mean score), and the calculation of the skewness statistics using SPSS shows that the organized activities measure appears quite skewed (*skewness statistic = 0.962,* s.e. = .101).[1] Because the variable is quite positively skewed, with more than 40% of respondents reporting participation in either 0 or 1 activities, we transformed the variable into a binary measure (1 = zero or one activity, 0 = 2 or more activities) based on the distribution of reported participation in these children. Next, we ran a non-parametric test to examine a possible age by DCD interaction (Mantel-Hanzel test). This was done by performing a logistic regression with the binary variable for organized play as the dependent measure. We regressed the transformed organized play variable on age, DCD status, and the interaction between DCD status and age (the model also adjusted for gender, height, and weight). The results are consistent with those reported using the ANCOVA—there is no evidence of an age by DCD interaction with organized play (OR for the interaction term = 1.13, p = .779).

We report similar results for Free Play. Analysis of skewness revealed that unlike the Organized Play sub-indices, this variable was not positively or negatively skewed (skewness = -.061). While there was evidence of a main effect of DCD on free play, there was no evidence of either a main effect of age or an age by DCD interaction on free play in these data.

Table 1 ANCOVA Results for Participation in Organized and Free Play Indices

	DCD		Age		DCD by Age		Gender		Weight (kg)		Height (m)	
Indices	$F(1, 572)$	η^2	$F(2, 572)$	η^2	$F(2, 572)$	η^2	$F(1, 572)$	η^2	$F(1, 572)$	η^2	$F(1, 572)$	η^2
Organized activities	6.91**	.012	1.50	.005	1.51	.005	.278	.000	1.92	.003	7.70***	.013
Free play	5.17*	.010	2.67	.010	.953	.003	6.42**	.011	.554	.001	.132	.000

Note. η^2 = Partial Eta-squared ***$p < .001$; **$p < .01$; *$p < .05$.

Table 2 Participation in Organized and Free Play Mean Scores Across Three Age Groups for Children With and Without DCD

	Ages 9 to 10		Ages 11 to 12		Ages 13 to 14	
Indices	DCD (n = 11)	No-DCD (n = 161)	DCD (n = 21)	No-DCD (n = 222)	DCD (n = 12)	No-DCD (n = 154)
Organized play						
M	4.27	5.22	1.52	6.03	2.83	4.98
SD	4.73	5.23	1.91	5.85	3.79	5.46
Free play						
M	14.73	15.05	12.05	14.63	11.42	13.72
SD	3.50	5.12	4.55	4.26	4.40	4.10

Discussion

Consistent with the findings of Bouffard et al. (1996), we found no evidence to support the divergence in activity-deficit with age hypothesis using a sample with a broader age range of children (ages 9 to 14) and when participation in both structured and unstructured play opportunities are considered. Moreover, even though the outcome or dependent variables in both these studies were different (self-reported versus observational measures), the results were congruous. When considered together, the results of our study, and Bouffard et al. (1996), suggest that even though children with DCD seem to be less likely to participate in vigorous free play or organized activities, the deficit does not change with age—at least from ages 6 to 14 (age range for both studies combined).

Before we conclude that age does not influence the relationship between DCD and physical activity, however, we must be careful to note the limitations inherent in both studies that may account for the failure to find support for this hypothesis. Among the most important, in our view, is the relatively small sample size of children with DCD in both studies. For example, in Bouffard et al. (1996), there were a total of 52 children (in both groups), meaning that only 26 children with movement problems were observed in their study. The authors do not report the gender or age composition of this group; however, even if we assume an equal distribution of children across the 6- to 9-age group, there were only a very small number of children (approximately 6 to 7 children in each age group). The power to detect a significant age effect, let alone an age by movement problem interaction is low. Similarly, in our study, while we had a much larger, overall sample (n = 581) and a larger number of children with probable DCD (n = 44), when broken down into smaller age-groupings, the number of children in each age bracket was relatively small. Therefore, the statistical power to detect a DCD by age interaction is also low in our study. This is illustrated by examining the differences in organized and free play activities between children with and without DCD in each of the three age groups (see Figures 1 and 2). For organized activities, the relative difference between children with and without DCD in the 9- to 10-year age group is small (less than one). Since the participation questionnaire is coded into "activity units," the interpretation of this difference is relatively straightforward—children with DCD participate, on average, in one less organized activity (e.g., participation in a school sports team) than children without DCD. This, however, changes quite dramatically in the 11- to 12-year age group. The difference in number of organized activities increases to more than four. The gap is smaller, but still relatively large in the oldest age group where children with DCD participate, on average, in two less organized activities when compared with their motor proficient peers. A similar, albeit less pronounced difference is observed with free play activities—differences in participation are slight in the 9- to 10-year age group (less than one), but in the two older age cohorts, children without DCD participate on average in two more free play activities than children with DCD. Together, these results suggest that the deficits in organized and free play between children with DCD and those without do appear to be greater in older age cohorts. Yet, with only a small number of children with DCD in each of these age groups, the standard errors are simply too large, and we fail to find evidence for a significant age by DCD interaction.[2] We feel it is imperative to examine this question again with a larger number of children with DCD.

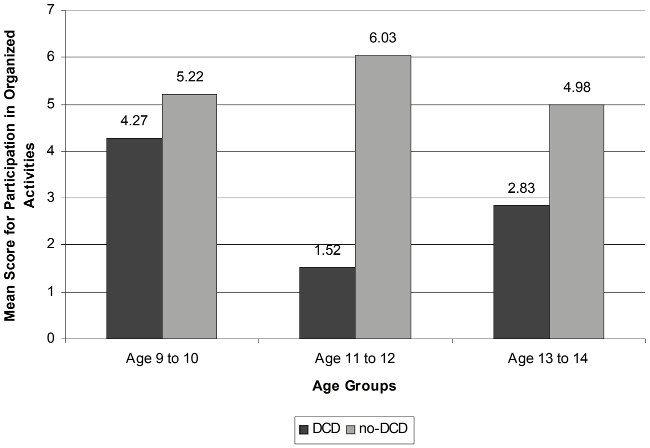

Figure 1 — Mean scores for children with and without DCD for participation in organized play by age.

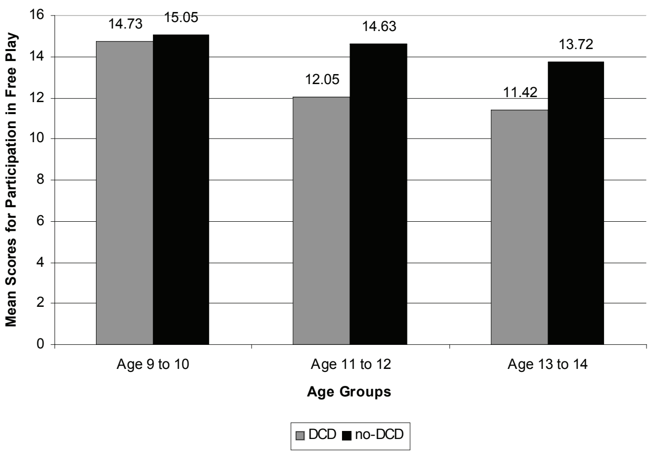

Figure 2 — Mean scores for children with and without DCD for participation in free play activities by age.

Beyond sample size issues, the reason we failed to find support for the divergence in activity deficit with age hypothesis may be due to the relatively gross nature of the PQ. Specifically, we cannot assess with this instrument whether specific reported activity units are, in fact, equal. For example, a child with probable DCD may report participating in cycling after school, but is not, in fact, as active in that pursuit as a child without DCD who also reports this activity. Second, the PQ is a self-reported measure of physical activity. To what extent social desirability may be affecting responses, particularly in children with DCD, is not known. Although the participation questionnaire used in this study has good psychometric properties (Hay, 1992), it would be interesting to use other forms of measurement to assess convergence such as pedometers or accelerometers.

The present study has extended the age range of previous work (Bouffard et al., 1996); however, the failure to find a significant age by DCD interaction may be because our age span is still not broad enough. Our results and those of Bouffard et al. (1996) suggest that children with DCD participate in fewer physical activities from about age 6 to age 14 (grade 1 through grade 8 in Canadian schools). Assuming, as the data suggest, that the deficit is constant during this period, it may still be the case that greater differences in physical activity do not emerge until mid to late adolescence. Again, this may be particularly true for organized sports, which become increasingly competitive in high school and where children can exercise greater autonomy in their choices. We know of no study that has examined whether adolescents (ages 12 to 19) with DCD participate in fewer activities than others of the same age. Further work should examine this question with this population.

From a policy perspective, even though the gap in physical activity between children with and without DCD does not seem to change with age, it is troubling that children with DCD report lower levels of participation in both free play and organized activities. As stated at the outset of the paper, greater hypo-activity in this population may lead to increased risk for health problems later in life. That DCD may be a risk factor for future health problems has received only limited attention in the literature. Interventions designed to encourage greater up-take of both discretionary and organized activities in this group is warranted. Since it is unlikely that the motor problems associated with DCD can be permanently corrected, interventions designed at finding suitable activities and working toward building confidence and efficacy with regard to participation are apt to hold the greatest promise for increasing physical activity levels in children with the condition (Chen & Cohn, 2003; Segal, Mandich, Polatajko, & Cook, 2003).

Finally, there are several other limitations in these data that need to be addressed in future work. First, as mentioned above, these data are based upon self-reported measures. While we have some concern over the limitations of the PQ, it is interesting to note that our findings are consistent with the findings of Bouffard et al. (1996), who used observational measures of children's physical play. Nevertheless, more research with varied measures of physical activity (self-reports, observations, direct measurements) is required to ensure our findings are not simply due to measurement. Multiple methods of measurement are always preferred but often lead to significant compliance problems and were beyond the scope of this investigation. Second, both our study and previous work have relied on cross-sectional methodologies to assess the relationship between DCD, age, and physical activity. Thus, it is not clear whether the results of these studies represent true differences due to aging (aging effect) or are simply due to cohort differences between children (a cohort effect). A better design would be to follow the same group of children over time and observe subsequent changes in play behavior. Although there have been a few longitudinal studies of DCD in children and adolescents (e.g., Geuze & Börger 1993; Cantell et al., 2003), we know of none that have tracked changes in physical activity over time. Third, we could not examine with these data, whether specific kinds of motor impairment (e.g., fine motor coordination problems) affect participation in free play and organized activities. Although the kinds of coordination problems children with DCD have are varied (Visser, 2003), whether children with particular clusters of motor problems are more likely than others to withdraw from activities is an important research question in need of further investigation. Closely related to this point, there is considerable variation in the severity of motor impairments in children with DCD. Further work should also consider whether severity impacts on participation in physical activity and whether or not the activity-deficit is particularly pronounced in children with severe coordination problems. Clearly, future work must address this gap in the literature.

Our results support a growing body of work that documents an activity-deficit in children with DCD (Bouffard et al., 1996; Cantell et al., 1994; Gubbay, 1975; Hands & Larkin, 2002; Schoemaker & Kalverboer, 1994; Wall, 1982). While it may be the case that this deficit does not change with age, sample size limitations warrant caution. We believe further work with a larger sample of children with DCD in a longitudinal design is necessary to properly test the divergence in activity-deficits with age hypothesis.

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End Notes

1. Values close to 1 indicate a problem with skewness.

2. We also ran an age by DCD interaction with a dichotomous variable for age (9 and 10 years in one group, 11 to 14 years in the other). The results are the same. We did not find a significant DCD by age interaction.